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(54) **TELE-OPERATION SYSTEM AND CONTROL METHOD THEREOF**

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B25J 13/00 (2006.01)
G06F 3/01 (2006.01)

(52) **U.S. Cl.**
CPC .. ***B25J 3/00*** (2013.01); ***B25J 13/00*** (2013.01); ***G06F 3/017*** (2013.01); *G05B 2219/35444* (2013.01); *G05B 2219/39449* (2013.01); *G05B 2219/39451* (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/017; B25J 3/00; B25J 13/00; A61B 2017/00207; G06K 9/00355; G06K 9/00375; G05B 2219/39449; G05B 19/39451; G05B 19/35444
USPC 703/1; 700/245, 250–252, 257–259; 463/31; 348/114
See application file for complete search history.

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(57) **ABSTRACT**

A tele-operation system enabling a robot arm to move by following a motion of a motion of a hand of a user without an additional mechanical apparatus, the tele-operation system including a slave robot having a robot arm, a master console configured to detect a gesture of a user, and to control the slave robot from a remote place so that the slave robot moves by following the gesture of the user.

21 Claims, 8 Drawing Sheets

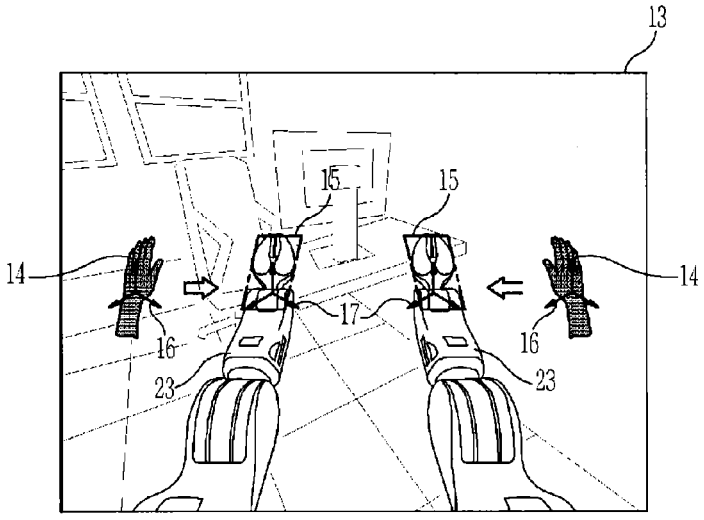

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FIG. 1

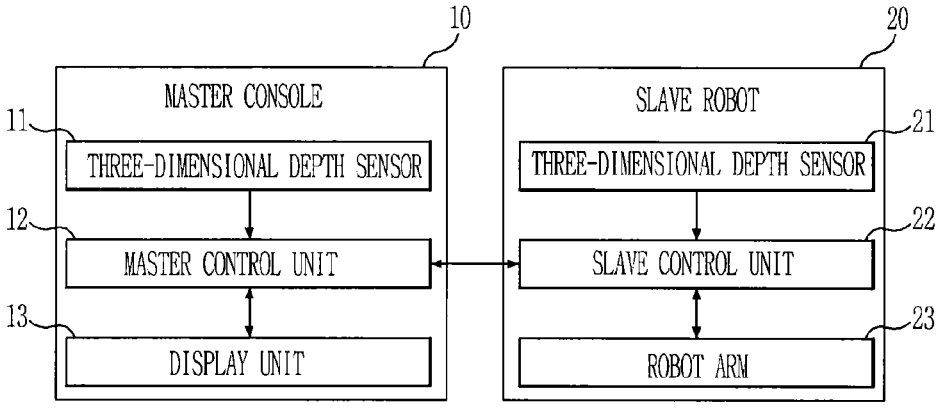

10
20
MASTER CONSOLE
SLAVE ROBOT
11
21
THREE-DIMENSIONAL DEPTH SENSOR
THREE-DIMENSIONAL DEPTH SENSOR
12
22
MASTER CONTROL UNIT
SLAVE CONTROL UNIT
13
23
DISPLAY UNIT
ROBOT ARM

FIG. 2

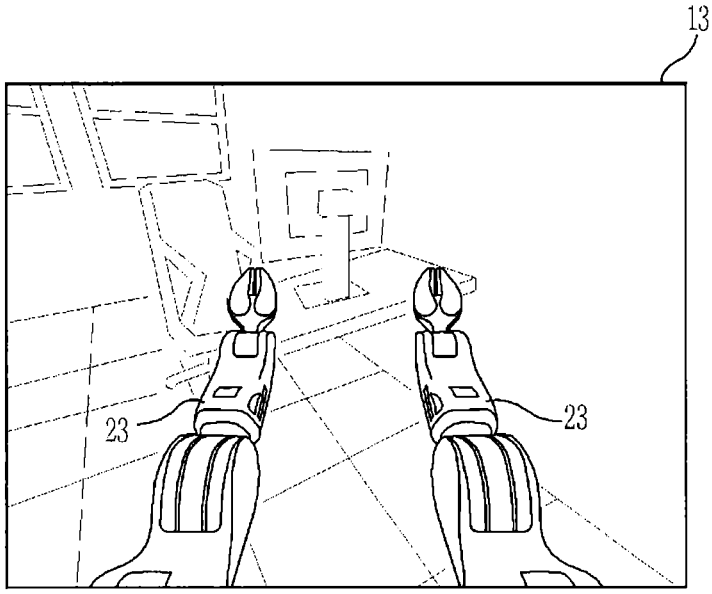


FIG. 3

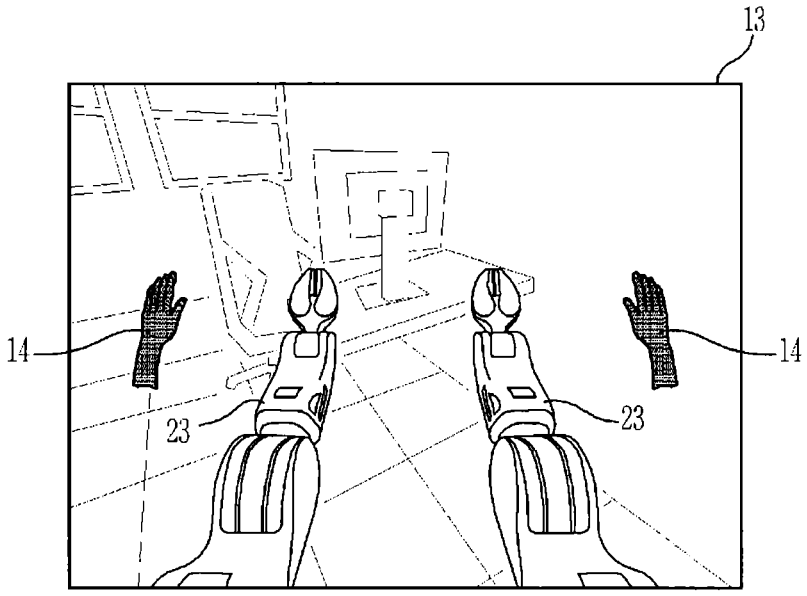


FIG. 4

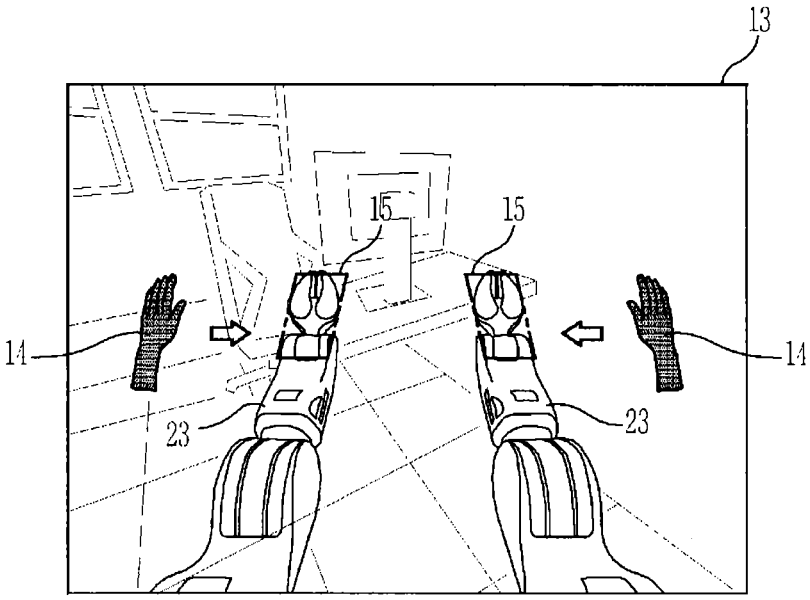


FIG. 5

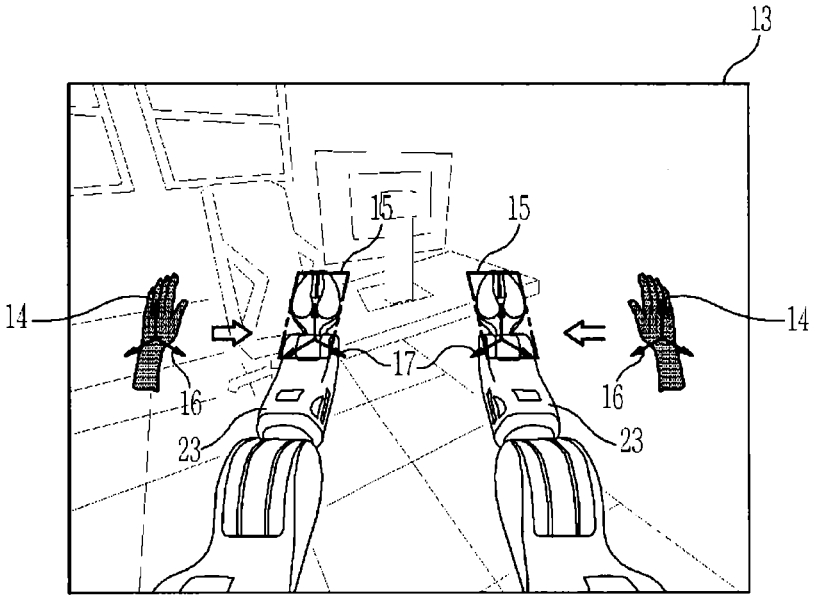


FIG. 6

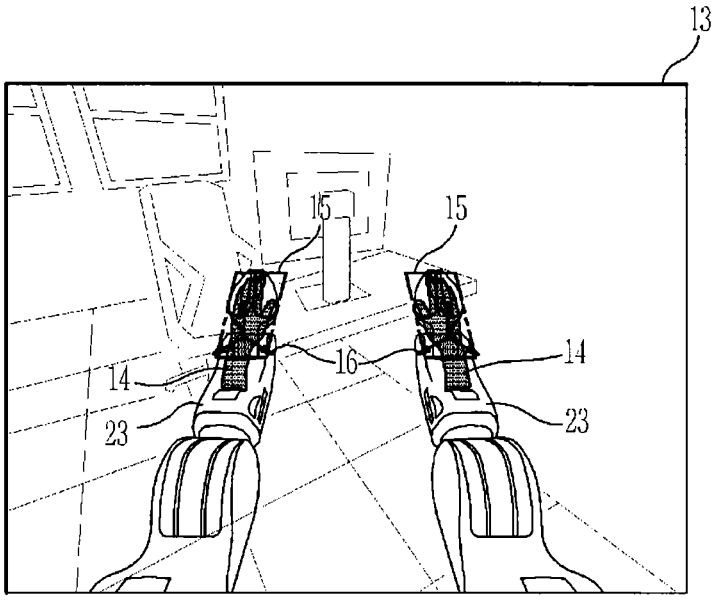


FIG. 7

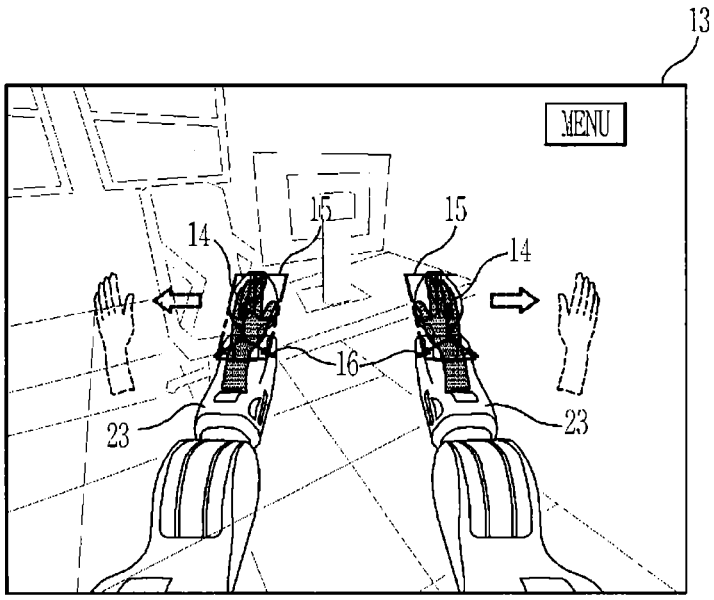
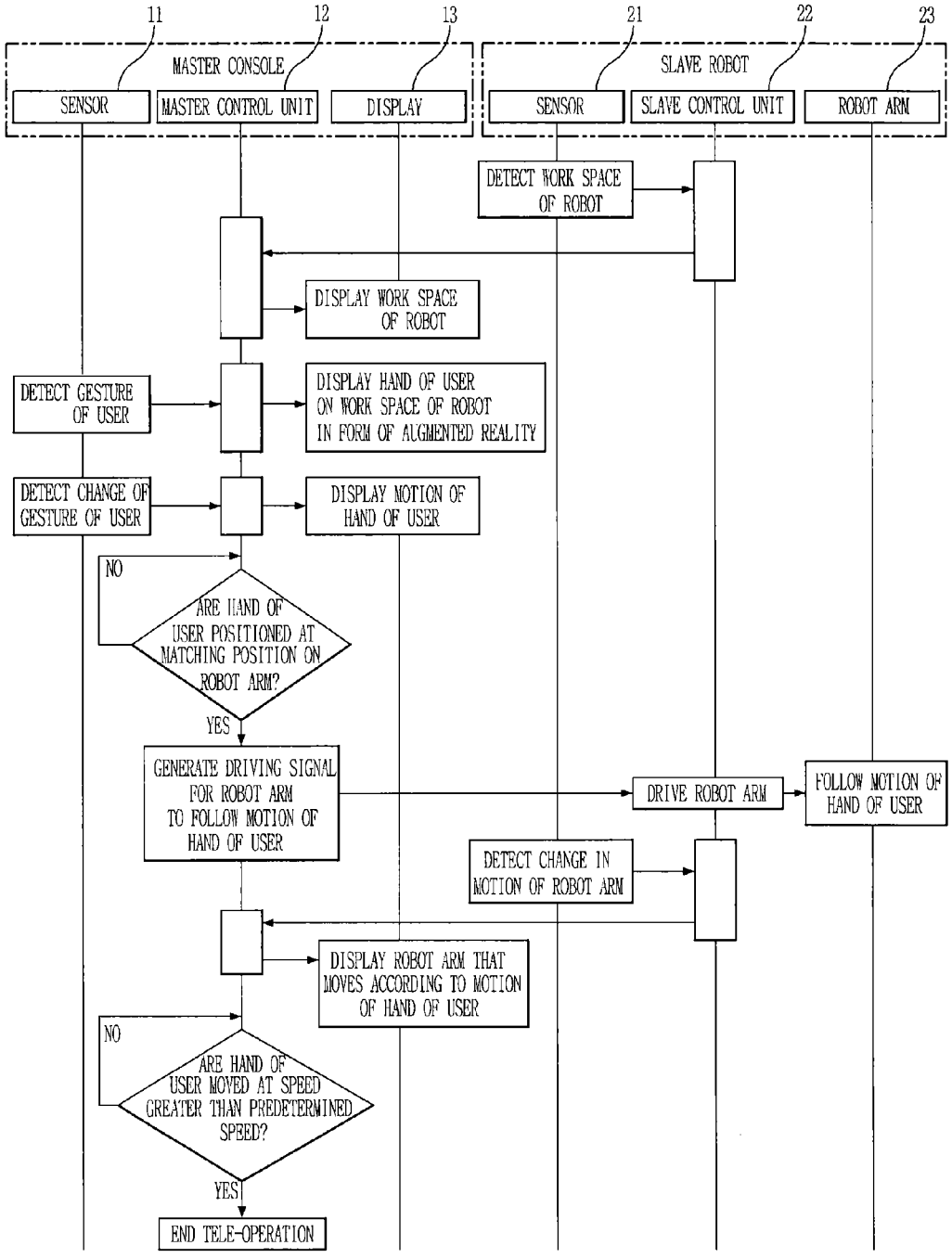


FIG. 8


11
12
13
21
22
23
MASTER CONSOLE
SENSOR
MASTER CONTROL UNIT
DISPLAY
SLAVE ROBOT
SENSOR
SLAVE CONTROL UNIT
ROBOT ARM
DETECT WORK SPACE OF ROBOT
DISPLAY WORK SPACE OF ROBOT
DETECT GESTURE OF USER
DISPLAY HAND OF USER ON WORK SPACE OF ROBOT IN FORM OF AUGMENTED REALITY
DETECT CHANGE OF GESTURE OF USER
DISPLAY MOTION OF HAND OF USER
NO
ARE HAND OF USER POSITIONED AT MATCHING POSITION ON ROBOT ARM?
YES
GENERATE DRIVING SIGNAL FOR ROBOT ARM TO FOLLOW MOTION OF HAND OF USER
DRIVE ROBOT ARM
FOLLOW MOTION OF HAND OF USER
DETECT CHANGE IN MOTION OF ROBOT ARM
DISPLAY ROBOT ARM THAT MOVES ACCORDING TO MOTION OF HAND OF USER
NO
ARE HAND OF USER MOVED AT SPEED GREATER THAN PREDETERMINED SPEED?
YES
END TELE-OPERATION

TELE-OPERATION SYSTEM AND CONTROL METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2012-0015542, filed on Feb. 15, 2012, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field

Embodiments of the present disclosure relate to a tele-operation system capable of controlling a robot from a remote place.

2. Description of the Related Art

A tele-operation system is being developed that controls a robot, which is performing a work, from a safe, remote place apart from a working environment.

Particularly, various tele-operation technologies are being introduced to control a robot, which is provided with robot arms, from a remote place for the robot to perform various works.

As for the tele-operation technologies as such, a method of tele-operating a robot by use of a joystick by a user, and a method of controlling a robot as a user wears a mechanical master apparatus are generally known.

The tele-operation technologies as such provide a control environment that is not intuitive as a result of implementing a motion of robot arms by use of a mechanical command in the form of mapping or conversion, and the motion of a user and the motion of the robot are not matched with each other, longer time is needed for the user to become familiar with the controlling of the robot arms, and in a case of a complicated work, a difficulty is present in controlling the robot arms in a swift manner.

SUMMARY

Therefore, it is an aspect of the present disclosure to provide a tele-operation system configured in a way that the robot arms are moved by following the motions of the hands of a user without a separate mechanical apparatus.

Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

In accordance with one aspect of the present disclosure, a tele-operation system includes a slave robot and a master console. The slave robot may include a robot arm. The master console may be configured to detect a gesture of a user, and to control the slave robot from a remote place so that the slave robot moves by following the gesture of the user.

The slave robot may include a sensor configured to detect a work environment of the slave robot.

The sensor may include a three-dimensional depth sensor (3D depth sensor).

The slave robot may include a slave control unit that may be configured to transmit information detected by the sensor to the master console, and to control the robot arm according to a command of the master console.

The slave control unit may be configured to determine space coordinates of the robot arm through the sensor, and to transmit the determined space coordinates of the robot arm to the master console.

The slave control unit may be configured to receive space coordinates of a hand of the user from the master console and convert the received space coordinates to be suitable for the space coordinates of the robot arms, and to transmit the converted space coordinates to the master console.

The slave control unit may be configured to control the robot arm by converting the command of the master console to be suitable for the space coordinates of the robot arm.

The master console may include a sensor to detect the gesture of the user.

The sensor may include a three-dimensional depth sensor (3D depth sensor).

The master console may include a display unit configured to display an image showing the work environment of the slave robot transmitted from the slave robot, and to display the gesture of the user detected by the sensor on the image in a form of augmented reality.

The display unit may be configured to display the robot arm of the slave robot, display a hand of the user detected by the sensor in a form of augmented reality, and display a matching position, at which the hand of the user being displayed in the form of augmented reality is needed to be positioned to control a motion of the robot arm.

The display unit may be configured to display a space coordinate system of the hand of the user and a space coordinate system of the robot arm.

The display unit may be configured to display various information provided to manipulate the slave robot.

The tele-operation system may further include a master control unit. The master control unit may be configured to transmit a driving signal to the slave robot so that the slave robot moves by following the gesture of the user detected by the sensor.

The master control unit may be configured to determine space coordinates of the hand of the user through information detected by the sensor.

The master control unit may be configured to transmit the determined space coordinates of the hand of the user to the slave robot.

The master control unit may be configured to receive space coordinates of the robot arm from the slave robot, and to convert the received space coordinates of the robot arm to be suitable for the space coordinates of the hand of the user.

The master control unit may be configured to transmit the converted space coordinates to the slave robot.

The master control unit, when the hand of the user is moved after the hand of the user is positioned at the matching position of the robot arm that is displayed on the display unit, may be configured to transmit a driving signal to the slave robot so that the robot arm of the slave robot moves by following a motion of the hand of the user.

The master control unit, when the hand of the user positioned at the matching position of the robot arm is moved at a faster speed than a predetermined speed, may be configured to stop a tele-operation of the slave robot by stopping transmitting the driving signal to the slave robot.

In accordance with another aspect of the present disclosure, a method of controlling a tele-operation system having a master console and a slave robot is as follows. A robot arm of the slave robot and a hand of a user on a display unit of the master console may be displayed. Whether the hand of the user displayed on the display unit is matched to the robot arm displayed on the display unit may be determined. A driving signal may be transmitted to the slave robot positioned at a remote place from the master console if the hand of the user displayed on the display unit is matched to the robot arm of

the slave robot displayed on the display unit, so that the robot arm of the slave robot moves by following a motion of the hand of the user.

The displaying of the robot arm of the slave robot and the hand of the user on the display unit of the master console is achieved by performing as follows. The robot arm may be displayed on the display unit of the master console. The hand of the user may be displayed on the display unit in a form of augmented reality by detecting a gesture of the user. A matching position, at which the hand of the user being displayed in the form of augmented reality is needed to be positioned to control the motion of the robot arm of the slave robot, may be displayed on the robot arm.

The determining of whether the hand of the user displayed on the display unit is matched to the robot arm displayed on the display unit may be achieved by performing as follows. Whether the hand of the user is positioned at the matching position being displayed on the robot arm and whether space coordinates of the hand of the user are matched with space coordinates of the robot arm may be determined.

The transmitting of the driving signal to the slave robot positioned at the remote place from the master console, so that the robot arm of the slave robot moves by following the motion of the hand of the user may be achieved by performing as follows. The motion of the hand of the user may be detected by the master console. A driving signal may be transmitted to the slave robot, so that the robot arm of the slave robot positioned at the remote place from the master console moves by following the motion of the hands of the user.

As described above, a robot at a remote place may be intuitively controlled by a user.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a block diagram showing the configuration of a tele-operation system in accordance with one embodiment of the present disclosure.

FIG. **2** is a drawing showing a work space of a slave robot being displayed at a display unit of a master console in accordance with one embodiment of the present disclosure.

FIG. **3** is a drawing showing the hands of a user being displayed at the display unit of the master console in the form of an augmented reality in accordance with one embodiment of the present disclosure.

FIG. **4** is a drawing showing matching positions, at which the hands of the user are needed to be matched, displayed at the robot arms displayed at the display unit of the master console in accordance with one embodiment of the present disclosure.

FIG. **5** is a drawing showing a space coordinate system being displayed at the hands of the user and the robot arms, which are displayed at the display unit of the master console, in accordance with one embodiment of the present disclosure.

FIG. **6** is a drawing showing the hands of the user being positioned at the matching positions of the robot arms displayed at the display unit of the master console in accordance with one embodiment of the present disclosure.

FIG. **7** is a drawing showing the hands of the user, which are displayed at the display unit of the master console, being diverged from the matching positions displayed at the robot arms in accordance with one embodiment of the present disclosure.

FIG. **8** is a flow chart showing a motion of a tele-operation system in accordance with one embodiment of the present disclosure.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

FIG. **1** is a block diagram showing a structure of a tele-operation in accordance with one embodiment of the present disclosure, FIG. **2** is a drawing showing a work space of a slave robot being displayed on a display unit **13** of a master console **10** in accordance with one embodiment of the present disclosure, and FIG. **3** is a drawing showing hands **14** of a user on the display unit **13** of the master console **10** in the form of an augmented reality in accordance with one embodiment of the present disclosure.

The tele-operation system includes the master console **10** and the slave robot **20**.

The master console **10** is configured to provide a manipulation environment so that a user may be able to manipulate the slave robot. The master console **10** is positioned at a remote place from the place at which the slave robot is positioned, and is configured for a user to manipulate the slave robot at the remote place at which the master console **10** is positioned.

The master console **10** includes a sensor **11**, a display unit **13**, and a master control unit **12**.

The sensor **11**, by detecting the gestures of a user, delivers the information related to the gestures of the user to the master control unit **12**.

As for the sensor **11**, a three-dimensional depth sensor (3D depth sensor) may be used.

The 3D depth sensor **11** is configured to recognize the gestures of a user, and the 3D depth sensor **11** radiates infrared light, which is invisible to human eyes, in pixel units at a subject, and by receiving the infrared light being reflected from the subject, the distance per pixel is calculated. Based on the calculated by-pixel distance, a depth image of the subject is generated in real time to recognize the three-dimensional gesture of the subject.

The 3D depth sensor **11** includes an infrared light projector to radiate infrared light in pixel units, an IR CMOS to receive the infrared light being reflected and then returned, and a color CMOS to generate a color image.

The 3D depth sensor **11** may be integrated with the display unit **13** while mounted at the display unit **13**, or may be used separately from the display unit **13**.

The display unit **13** is configured to display a work environment of the slave robot.

FIG. **2** shows a work space of the slave robot being displayed at the display unit **13**. The slave robot also includes a sensor **21**, and the information, which is related to the work space of the surroundings of the slave robot, recognized by the sensor **21** is delivered to the master control unit **12**, and is displayed at the display unit **13**. The slave robot and the sensor **21** included in the slave robot will be described later.

As shown on FIG. **2**, at the display unit **13**, robot arms **23** being used at a work, as well as a work space at which a work of the robot arms **23** of the slave robot is performed, is displayed.

FIG. **3** is a drawing showing the hands **14** of a user at the display unit **13** of the master console **10** in the form of an augmented reality in accordance with one embodiment of the present disclosure.

As shown on FIG. **3**, the hands **14** of a user, which are detected at the sensor **11** of the master console **10**, are displayed at the display unit **13** by being added in the form of an augmented reality to the work environment of the slave robot, which is already displayed at the display unit **13**.

Since the gestures of the user are recognized by the sensor **11** of the master console **10**, when a change is taken place with respect to the motions of the hands of the user, the change as such is directly displayed on the display unit **13**.

That is, when a user moves the hands of the user in front of the display unit **13**, the motion of the user as such is detected at the 3D depth sensor **11**, and the motions of the hands of the user as such are displayed by being added to the image, which shows the work environment of the slave robot that is already being displayed, in the form of an augmented reality.

In addition, at the robot arms **23** of the slave robot being displayed at the display unit **13**, matching positions **15**, at which the hands **14** of a user being displayed in the form of an augmented reality are needed to be positioned to control the motions of the robot arms **23**, are displayed.

As shown on FIG. **4**, the matching positions **15** at which the hands **14** of a user are needed to be matched are displayed at the portions that correspond to the hands of the robot arms **23**.

Thus, a user may be able to position the hands **14** of the user at the matching positions **15** displayed at the robot arms **23** by moving the hands **14** of the user.

When the hands **14** of the user displayed at the display unit **13** as an augmented reality are positioned at the matching positions **15** and are matched with the matching positions **15**, the robot arms **23** follows the motions of the hands **14** of the user.

In order for the hands **14** of the user and the matching positions **15** displayed at the robot arms **23** to be precisely matched each other, coordinate systems **16** and **17** may be displayed at the hands **14** of the user and the matching positions **15** being displayed at the robot arms **23**, respectively.

As illustrated on FIG. **5**, a three-dimensional coordinate system **16** is additionally displayed at the hands **14** of a user displayed at the display unit **13** while a three-dimensional coordinate system **17** is additionally displayed at the robot arms **23** as well, and thus the user may be able to match the hands **14** of the user with the robot arms **23** in a further precise manner by having the coordinate system **16** displayed at the hands **14** of the user to be matched with the coordinate system **17** displayed at the matching positions **15** of the robot arms **23**.

When the hands **14** of the user are precisely positioned at the matching positions **15** of the robot arms **23**, the display unit **13** is configured to display a signal to notify the above to the user. The type of the signal is not limited hereto.

As illustrated on FIG. **6**, after the matching positions **15** of the robot arms **23** displayed at the display unit **13** are matched with the hands **14** of the user, when the user moves the hands **14** of the user to desired directions by referring to the display unit **13**, the robot arms **23** moves by following the movement of the above.

That is, the robot arms **23** of the slave robot positioned at a remote place afar from the master console **10** are moved in the same manner as the motions of the hands **14** of the user that are present at the place where the master console **10** is positioned, and an image of the robot arms **23** moving according to the motions of the hands **14** of the user is displayed at the display unit **13** of the master console **10**, so that the user may be able to acknowledge whether the robot arms **23** are in a proper course of following the motions of the hands **14** of the user. The detailed description of the above will be provided in the description of the master control unit **12**.

As illustrated on FIG. **7**, in a case when a user moves the hands **14** of the user at a speed greater than a predetermined speed, the hands **14** of the user are diverged from the matching positions **15**, and thus the motions of the robot arms **23** are stopped to a state where the robot arms **23** are at the time when the hands **14** of the user are diverged from the matching positions **15**.

That is, the user may stop a work or perform a different work by moving the hands **14** at a speed greater than the predetermined speed to diverge from the matching positions **15**.

At the display unit **13**, a menu bar is displayed, so that a user may perform various types of work through the menu bar.

The master control unit **12** is configured to calculate space coordinates of the hands **14** of a user on a user space through the information detected by the sensor **11** of the master console **10**, and the master control unit **12** also configured to receive space coordinates of the robot arms **23** of a robot space, which are calculated through the information detected by the sensor **21** of the slave robot, from the slave robot.

The master control unit **12** converts the space coordinates of the robot arms **23** on the robot space, which are received from the slave robot, into coordinates on the user space.

The master control unit **12**, by converting the space coordinates of the robot arms **23** into the coordinates on the user space as the above such that the robot arms **23** and the hands **14** of a user share the same coordinate space, enables the robot arms **23** to be displayed at the display unit **13** of the master console **10**, and also enables the hands **14** of the user to be displayed at the display unit **13** in the form of an augmented reality. Here, having the space coordinates of the robot arms **23** converted into the coordinates on the user space is described as one example, but the space coordinates of the hands **14** of a user may be converted into the space coordinates system on the robot space of the slave robot.

In addition, the master control unit **12** transmits the space coordinates of the hands **14** of a user, which are calculated through the information detected at the sensor **11** of the master console **10**, to the slave robot. The converting of the coordinates described above is preferred to be performed at the master control unit **12**, but the converting of the coordinates may be performed at the slave robot by having the space coordinate system of the hands **14** of the user transmitted from the master control unit **12** to the slave robot. In a case when the converting of the coordinates is performed at the slave robot, the slave robot may be able to transmit the converted coordinate information again to the master control unit **12**.

In addition, the master control unit **12**, as described above, when the hands **14** of a user and the robot **23** are matched with each other as the hands **14** of the user displayed at the display unit **13** are positioned at the matching positions **15** of the robot arms **23**, generates a driving signal and transmits the driving signal to the slave robot, so that the robot arms **23** of the slave robot at a remote place may follow the motions of the hands **14** of the user. The slave robot receives the driving signal of the master console **10**, and drives the robot arms **23** so that the robot arms **23** may follow the motions of the hands **14** of the user.

The master control unit **12**, prior to transmitting the driving signal, converts the driving signal to be suitable for the coordinates on the robot space, and then transmits the converted driving signal, or the driving signal transmitted from the master control unit **12** may be converted into the coordinates on the robot space at the slave robot.

When the robot arms **23** are moved according to the driving signal, the sensor **31** of the slave robot detects the motion of the robot arms **23**, and the slave robot transmits the information related to the actual motions of the robot arms **23** to the master control unit **12**. The master control unit **12**, through the information above, displays on the display unit **13** that the motions of the robot arms **23** are being changed by following the motions of the hands **14** of a user.

In order to confirm whether the motions of the robot arms **23** according to the driving signal are in a proper course of following the motions of the hands **14** of a user, the slave robot may transmit a feedback signal to the master control unit **12**. The master control unit **12**, by receiving the feedback signal as such, may adjust the driving signal by determining whether the motions of the robot arms **23** are in a proper course of following the motions of the hands **14** of the user.

The slave robot includes the sensor **21**, the robot arms **23**, and a slave control unit **22**.

The sensor **21** is mounted at the slave robot, and detects a work space at which the slave robot is positioned, as well as an object that is present at the work space, and transmits the information related to the above to the slave control unit **22**. The slave control unit **22** transmits the information detected by the sensor **21** to the master control unit **12**, so that the work space of the slave robot may be displayed at the display unit **13**.

As for the sensor **21**, the same as the sensor **11** of the master control **10** described above, a 3D depth sensor may be used. The description of the above will be omitted since the description of the above is same as the description with respect to the sensor **11** of the master console **10**.

The robot arms **23**, since the robot arms **23** move by following the motions of the arms of a human, are desired to be multi-joint robot arms **23** composed of multiple joints as the arms of a human. At the robot arms **23**, robot hands that correspond to the hands **14** of a human are desired to be provided, so that the robot hands may be able to grab an object. The number of the robot arms **23** is not limited, but is desired to be two units thereof or a one unit thereof.

The slave control unit **22** is configured to control the overall motions of the slave robot.

The slave control unit **22**, through the information detected at the sensor **21** of the slave robot, calculates space coordinates of the robot arms **23** on the robot space, and transmits such to the master control unit **12**. The master control unit **12** converts the space coordinates system of the robot arms **23** on the robot space, which are received from the slave robot, into coordinates on the user space.

In addition, the slave control unit **22**, by receiving space coordinates of the hands **14** of a user from the master control unit **12**, may be able to convert the received space coordinates of the hands **14** of the user into space coordinates on the robot space.

As described above, the converting of the coordinates as such may be performed while having the space coordinates on the robot space as a reference, or while having the space coordinates on the user space as a reference. Since the space coordinates of the hands **14** of a user and the space coordinates of the robot arms **23** of the slave robot, which exist at different spaces to each other, may be converted into the coordinates on the same space, the converting of the coordinates may be made by having the space coordinates on the robot space as a reference or by having the space coordinates on the user space as a reference, and the converting as such may be performed at the master control unit **12** or at the slave control unit **22**.

The slave control unit **22** drives the robot arms **23** by receiving the driving signal of the robot arms **23** from the master control unit **12**.

The slave control unit **22** converts the driving signal being transmitted from the master control unit **12** into coordinates on the robot space, and controls the motions of the robot arms **23** according to the converted driving signal.

Alternatively, prior to transmitting a driving signal from the master control unit **12**, the driving signal may be converted to be suitable for the coordinates on the robot space, and then the converted driving signal may be transmitted to the slave robot.

When the robot arms **23** are moved according to the driving signal, the sensor **21** of the slave robot detects the motions of the robot arms **23**, and the slave control unit **22** transmits the information related to the actual motions of the robot arms **23** to the master control unit **12**. The master control unit **12**, through the information as such, displays on the display unit **13** that the motions of the robot arms **23** are being changed by following the motions of the hands **14** of a user.

In order to confirm whether the motions of the robot arms **23** according to the driving signal are in a proper course of following the motions of the hands **14** of a user, the slave control unit **12** may transmit a feedback signal to the master control unit **12**. The master control unit **12**, by receiving the feedback signal as such, may determine whether the motions of the robot arms **23** are in a proper course of following the motions of the hands **14** of the user, and then may adjust the driving signal.

FIG. **8** is a flow chart showing a motion of a tele-operation system in accordance with one embodiment of the present disclosure.

As illustrated on FIG. **8**, a work space at which a work of the slave robot is being performed is detected by the sensor **21** of the slave robot, and the signal detected by the sensor **21** is transmitted to the slave control unit **22**.

The slave control unit **22** transmits the detected signal related to the work space to the master control unit **12**, and the master control unit **12** receives the signal, and controls the display unit **13** so that the work space at which a work of the slave robot is being performed is displayed at the display unit **13** of the master console **10**.

The sensor **11** of the master console **10** detects the gestures of a user, and transmits the signal detected by the sensor **11** to the master control unit **12**, and the master control unit **12** displays the hands **14** of the user on the display unit **13**, on which the work space where the slave robot is being performed is displayed, in the form or an augmented reality.

The sensor **11** of the master console **10** detects the change in the gestures of a user, and transmits the signal detected by the sensor **11** to the master control unit **12**, and the master control unit **12** displays the motions of the hands **14** of the user on the display unit **13**.

The master control unit **12** determines whether the hands **14** of a user displayed at the display unit **13** are positioned at the matching positions **15** displayed on the robot arms **23**.

The master control unit **12**, if determined that the hands **14** of the user are positioned at the matching positions **15** and that the hands **14** of the user are matched with the robot arms **23**, generates a driving signal that drives the robot arms **23** for the motions of the robot arms **23** to follow the motions of the hands **14** of the user, and transmits the driving signal to the slave control unit **22**.

The slave control unit **22** drives the robot arms **23** by receiving the driving signal. The slave control unit **22** may be able to convert the driving signal into the space coordinates on the robot space.

The robot arms **23** that move according to the driving signal are detected by the sensor **21** of the slave robot, and the sensor **21** transmits the detected signal to the slave control unit **22**, and then the slave control unit **22** transmits the detected signal as such to the master control unit **12**. The master control unit **12** receives the detected signal, and displays the robot arms **23**, which move according to the motions of the hands **14** of a user, on the display unit **13**.

A user positioned at the master console **10**, while checking the robot arms **23** of the slave robot that move according to the hands **14** of the user, adjusts the motions of the hands **14** of the user.

When the motions of the hands **14** of the user are performed at a speed greater than a predetermined speed, and the hands **14** of the user are diverged from the matching positions **15** displayed on the robot arms **23**, the master control unit **12** ends a tele-operation of the robot arms **23** until a next command is input by the user.

Although a few embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A tele-operation system, comprising:
a slave robot comprising a real robot arm; and
a master console configured to control the slave robot from a remote place so that the slave robot moves by following a real hand of a user, the master console including
a sensor configured to detect the real hand of the user,
a display unit configured to display the real robot arm of the slave robot in a form of augmented reality, display the real hand of the user detected by the sensor in the form of augmented reality, and display a matching position of the real robot arm, the matching position being a position at which the real hand of the user displayed in the form of augmented reality is matched to the real robot arm displayed in the form of augmented reality to begin to control a motion of the real robot arm.

2. The tele-operation system of claim **1**, wherein:
the slave robot comprises a sensor configured to detect a work environment of the slave robot.

3. The tele-operation system of claim **2**, wherein:
the sensor comprises a three-dimensional (3D) depth sensor.

4. The tele-operation system of claim **2**, wherein:
the slave robot comprises a slave control unit configured to transmit information detected by the sensor to the master console, and to control the real robot arm according to a command of the master console.

5. The tele-operation system of claim **4**, wherein:
the slave control unit is configured to determine space coordinates of the real robot arm through the sensor, and to transmit the determined space coordinates of the real robot arm to the master console.

6. The tele-operation system of claim **4**, wherein:
the slave control unit is configured to receive space coordinates of the real hand of the user from the master console and convert the received space coordinates to correspond to space coordinates of the real robot arm, and transmit the converted space coordinates to the master console.

7. The tele-operation system of claim **4**, wherein:
the slave control unit is configured to control the real robot arm by converting the command of the master console to correspond to space coordinates of the real robot arm.

8. The tele-operation system of claim **1**, wherein:
the sensor comprises a three-dimensional (3D) depth sensor.

9. The tele-operation system of claim **1**, wherein the display unit is configured to display an image showing a work environment of the slave robot transmitted from the slave robot, and display the real hand of the user detected by the sensor on the image in the form of augmented reality.

10. The tele-operation system of claim **9**, wherein:
the display unit is configured to display a space coordinate system of the real hand of the user and a space coordinate system of the real robot arm.

11. The tele-operation system of claim **9**, wherein:
the display unit is configured to display various information provided to manipulate the slave robot.

12. The tele-operation system of claim **1**, further comprising:
a master control unit configured to transmit a driving signal to the slave robot so that the slave robot moves by following the real hand of the user detected by the sensor.

13. The tele-operation system of claim **12**, wherein:
the master control unit is configured to determine space coordinates of the real hand of the user through information detected by the sensor.

14. The tele-operation system of claim **13**, wherein:
the master control unit is configured to transmit the determined space coordinates of the real hand of the user to the slave robot.

15. The tele-operation system of claim **12**, wherein:
the master control unit is configured to receive space coordinates of the real robot arm from the slave robot, and to convert the received space coordinates of the real robot arm to correspond to space coordinates of the real hand of the user.

16. The tele-operation system of claim **15**, wherein:
the master control unit is configured to transmit the converted space coordinates to the slave robot.

17. The tele-operation system of claim **12**, wherein:
the master control unit, when the real hand of the user moves after the real hand of the user is positioned at a position corresponding to the matching position of the real robot arm displayed on the display unit, is configured to transmit a driving signal to the slave robot so that the real robot arm of the slave robot moves by following a motion of the real hand of the user.

18. The tele-operation system of claim **17**, wherein:
the master control unit, when the real hand of the user positioned at the matching position of the real robot arm moves at a faster speed than a predetermined speed, is configured to stop a tele-operation of the slave robot by stopping transmitting the driving signal to the slave robot.

19. A method of controlling a tele-operation system having a master console and a slave robot, the method comprising:
displaying a real robot arm of the slave robot and a real hand of a user on a display unit of the master console;
determining whether a position of the real hand of the user displayed on the display unit is matched to a position of the real robot arm displayed on the display unit; and
transmitting a driving signal to the slave robot positioned at a remote place from the master console when the position of the real hand of the user displayed on the display unit is matched to the position of the real robot arm of the

slave robot displayed on the display unit, so that the real robot arm of the slave robot moves by following a motion of the real hand of the user,

wherein the displaying includes

displaying the real hand of the user on the display unit in a form of augmented reality by detecting a position of the real hand of the user, and

displaying a matching position of the real robot arm, the matching position being a position at which the real hand of the user displayed in the form of augmented reality is positioned to begin to control a motion of the real robot arm displayed in the form of augmented reality.

20. The method of claim **19**, wherein the determining comprises:

determining whether the real hand of the user is positioned at the matching position displayed on the real robot arm displayed on the display unit; and

determining whether space coordinates of the real hand of the user are matched with space coordinates of the real robot arm.

21. The method of claim **19**, wherein the transmitting comprises:

detecting the position of the real hand of the user by the master console; and

transmitting the driving signal to the slave robot, so that the real robot arm of the slave robot positioned at the remote place from the master console moves by following the position of the real hand of the user.

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